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Modeling of Rainfall-Runoff Correlations Using Artificial Neural Network-A Case Study of Dharoi Watershed of a Sabarmati River Basin, India

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Abstract

The use of an Artificial Neural Network (ANN) is becoming common due to its ability to analyse complex nonlinear events. An ANN has a flexible, convenient and easy mathematical structure to identify the nonlinear relationships between input and output data sets. This capability could efficiently be employed for the different hydrological models such as rainfall-runoff models, which are inherently nonlinear in nature. Artificial Neural Networks (ANN) can be used in cases where the available data is limited. The present work involves the development of an ANN model using Feed-Forward Back Propagation algorithm for establishing monthly and annual rainfall runoff correlations. The hydrologic variables used were monthly and annual rainfall and runoff for monthly and annual time period of monsoon season. The ANN model developed in this study is applied to Dharoi reservoir watersheds of Sabarmati river basin of India. The hydrologic data were available for twenty-nine years at Dharoi station at Dharoi dam project. The model results yielding into the least error is recommended for simulating the rainfall-runoff characteristics of the watersheds. The obtained results can help the water resource managers to operate the reservoir properly in the case of extreme events such as flooding and drought.

Keywords: Artificial Neural Networks (ANN); Feed-Forward Back Propagation Algorithm; Rainfall-Runoff Modeling.

1. Introduction

The rainfall-runoff relationship is one the most complex hydrological phenomenon due to the tremendous spatial and temporal variability of watershed characteristics and rainfall patterns as well as a number of variables involved in the physical processes [1]. Also, this process is non-linear in nature and thus difficult to arrive at solutions. The runoff needs to be estimated for efficient utilization of water resources. The rainfall-runoff models play a significant role in water resource management, planning and hydraulic design [2]. The study on rainfall-runoff relationship also helps in planning and developing distribution policies from the available water resources [3]. Evaluating this process with accuracy is what allows rational management of the different water uses, such as: supply, irrigation, electric power generation, to forecast extreme flood events and dry periods, to generate scenarios of streamflow from precipitation scenarios resulting from climate change and others [4]. Generally mathematical models known as rainfall-runoff models perform the evaluation of this process. Rainfall-runoff models are divided into two major groups: conceptual and empirical models. The conceptual models describe mathematically the processes of the hydrologic cycle based on physical laws governing each of these processes [5]. However, despite generally good results are achieved, some aspects of the conceptual models are challenging. Calibration is not easy and in many cases, depends on field surveys of data often not available. Also, the use of basin averages for relevant parameters together with the nonlinear character of those processes leads to additional difficulties [6]. These characteristics often render the implementation

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